Anna Lipkin
21 April 2014

**Paradoxical Control: How Romantic and Enlightenment aesthetics are created in ballet today**

Arvo Pärt's haunting 'Spiegel im Spiegel' and a pale pink lotus painting with the quality of stained glass serve as the backdrop for Helen Pickett's delicate pas de deux *Tsukiyo*, premiered by Boston Ballet in 2009. The female half of the duet is a somewhat inhuman creature, with splayed fingers, moments of disjointed movement, and lifted shoulders. Her interactions with her partner are cautious, hesitant; she uses her pointe shoe to softly lift his leg off the floor, her tense hands revealing both her nervousness and her desire. The image of reaching is also revisited throughout the ballet. In one touching moment, the female character seems to be pulled by the energy of her yearning for her partner; her arm fully extended behind her, a twist of her wrist sends her running back into her partner's arms. While her beautifully extended and involved lines convey her attraction to her partner, the tenseness in different parts of her body (shoulders, hands, neck, elbows) show her hesitation as well as create the idea that she is something other than human, something perhaps more delicate, more vulnerable. Her delicate, almost precarious balance in her walks forward en pointe reinforces this idea of the dancer as otherworldly.

Besides the fact that the dancer wears pointe shoes, what exactly defines this piece as a ballet rather than a modern dance work? Though the choreographer does alter some of the traditional aesthetics of the art form to convey her chosen theme, for the most part, the aesthetic values and narrative subject matter of the piece are in line with the values often associated with ballet. But why does ballet look the way it does? What are the images and illusions dancers try to create, why, and how do they try to create them? Is there a historical basis? A physical basis? A

neurological basis? How can we begin to understand how exactly the expressivity shown by this dancer and by dancers in traditional ballet is created and translated to the audience.

Classical ballet is indisputably a cultural product: its forms, themes, and images all derive from the cultures and time periods in which the dance form was created and developed. Two especially important times in the shaping of ballet as it is recognized today were the Enlightenment and the Romantic era. The most important aesthetic results of these contexts are the idea of perfection through symmetry and geometric form, the imagery of yearning tension, and the illusion of weightlessness and ethereality, the defiance of gravity. While superficially opposed, one glorifying the rational and the other idealizing the unexplainable, the two movements in fact merged harmoniously in dance, and this combination itself gives ballet its particular aesthetic. Both cultural contexts are necessary to understand ballet as we see it today. Gravity-defying feats take a great deal of control. In order not to simply drop her leg but to float it slowly to the ground, a dancer must employ a great deal of core and leg strength—without letting it show. It is here, in this use of control to create the illusion of freedom, that the ideals of the Enlightenment and the Romantic era meet and merge to create and execute the specific aesthetic ideals of ballet. In this paper, after introducing the cultural and historical bases of the particular aesthetics of ballet, I will attempt to explain, using the laws of physics, how the image of weightlessness and suspension is created in the movement vocabulary of ballet. I will also outline how a dancer, understanding the laws and predictions of physics, can use this understanding to consciously extend her body and her dancing to appear just past the limits of gravity in order to create the illusion promoted by Romantic era ideals. A final section will discuss how these illusions are conveyed to an audience through the lens of neuroscientific inquiry, another significant product of the Enlightenment. These discussions will also highlight

the overarching theme that unifies these three disparate points: a desire to attain the unattainable and the worth of the endeavor towards that unachievable goal. I wish to highlight the at-first paradoxical cooperation of the ideas of the Enlightenment and the Romantic era by showing their interdependence to create the aesthetic of ballet. The Enlightenment posits physics, empiricism, and logical thought as the most valuable ways to understand the world while Romanticism seeks to display that which cannot be understood. Ballet takes both and combines them, using physics to predict how the world *should* work and then going against that expectation to create the illusion of being unaffected by these laws.

**The Enlightenment: Perfection through Geometric Form, Number, and Symmetry**

The Enlightenment offered a welcome respite from the disease, discord, and mystery of the Middle Ages, during which the Church had high, unquestionable authority and human suffering was an unavoidable punishment for original sin (Chisick 2005). In stark contrast, Sir Isaac Newton revealed in his *Principia Mathematica* (1687) a world that could be described and predicted empirically rather than philosophically, a worldview that would carry through into today's reductionist method of making the world understandable and digestible (Toulmin 1992). Extending this importance of empiricism, John Locke posited the individual as a blank slate, a *tabula rasa* at birth, receiving all knowledge through his senses alone, which introduced a concept of human nature as malleable rather than inherently sinful or predestined (Chisick 2005). These two ideas combined to create a drastically new scientific and rational approach to the world and dramatically changed the way people viewed their existence in this world. Whereas before, life was unpredictable, terrifying, awesome, now Newton and Locke, with other Enlightenment *philosophes*, created a framework by which nature and life could become

predictable, the world "a more intelligible and less mysterious place than it had previously seemed" (Chisick 2005, 14).

Another important philosopher of the early Enlightenment was René Descartes, who in his final philosophical work, *Les Passions de l'Ame* (1649), discusses the relationship between the body, the brain, and the soul. Drawing inspiration from clocks and other automata, Descartes viewed human beings as comparably mechanical, just like all other living things. However, humankind was endowed with reason, a mind, a soul, which could interact with the mechanistic body through the pineal gland:

> The passions affect the mind by means of a naturally established relation between their particular physical manifestations and the character of the mind's apprehension of them through their effect on the flow of (entirely material) "animal spirits" through the pineal gland in the brain…But they can also themselves be affected by the mind, again by the redirection of spirits through the pineal gland (Dear 1998, 117).

Descartes' *Les Passions de l'Ame* serves not only to reinforce the idea of the brain as the principal seat or transmitter of reason, which functions as a precursor to today's emphasis on neuroscience as a path to understanding the human mind and behavior. It also emphasizes the importance and ability of the mind to control the actions of the body, tying an element of morality to proper comportment and physical behavior (such as court dancing), such that the "fear of missteps was a fear of revealing to competent members of court society that they did not possess full membership in that moral community" (Dear 2003, 113). Thus, just as ballet began to emerge as indicator of social status in the French court, the Enlightenment emphasis on self-discipline and manners as well as the view of the brain as a tool in understanding behavior and emotion were also coming to the forefront in European thought.

The Enlightenment, in its attempt to break away from the dogmatic authority of the Church, turned instead to Greek philosophical and pagan knowledge (Chisick 2005, 11). Neo-

Platonism was one such approach, borrowing from the Greek classical ideals of Apollonian perfection, rationalism (though only when based on empirically discovered facts), and the divinity of numbers. For Pythagoras, a Greek philosopher born around 570 BC, material reality was built out of immaterial number. Creation could be seen as an expression of an essentially harmonic and mathematical structure, divinely rational (Robinson 2004). The order of the universe, rather than its inscrutable mystery, became a symbol of the divine. Neo-Platonism placed man on a chain of existence in the natural world, from the lowest animals to God (Homans 2008); Humanism, a consequence both of Locke's blank slate concept and Newton's idea of the universe as ordered, encouraged him to rise up through these ranks, using mathematical order to attain a status closer to God (Homans 2008) While Enlightenment thinking seemed to emphasize the divine, its true focus was on the power and perfectibility of man. This is naturally reflected in its art forms, notably French court dance from Catherine de Medici to Louis XIV (1581-1715).

The extravagant spectacle of the French courts consciously and explicitly absorbed themes of Enlightenment thought into its form and subject matter. Dance was seen as a means to resolve conflict, to bring order, and to increase morality of men, as French King Charles IX "believed that when music is disordered, morals become depraved, but when music is well ordered, men are morally disciplined" (Lee 2002, 40). This belief could logically be extended to disciplined dance as well. The emphasis on order, and the divinity of mathematics, was manifested in the geometry of floor patterns, which gave an overall effect of reflecting cosmic harmony (Lee 2002, 27), showing that "number, geometry, and reason ordered the universe" (Homans quoting Yates 2010, 8). In the *Ballet Comique de la Reine*, created to celebrate the marriage of the Duc de Joyeux to Marguerite of Lorraine in the court of Catherine de Medici

(Lee 2002, 44), the dancers traced complex and constantly changing shapes across the floor, each communicating a specific message. This same idea of geometric floor patterns in flux can be seen in the more recent work of George Balanchine, for example in *Symphony in Three Movements*, where the white-leotard-clad *corps* dancers melt from a diagonal line to a circle to multiple pockets of dancers as principal dancers in bright pink leotards create shapes within those changing patterns. While each floor pattern in the time of the court dance had a very specific meaning, for example, a triangle signifying truth, ballet today does not associate certain meanings with particular formations. Modern dance has neoclassical trends in terms of its reference to mythology in its subject matter and Greek sculpture in its forms, but the trend of geometry serves as an example of neoclassicism as well. In modern dance pioneer Doris Humphrey's treatise on choreography (1959), she highlights some of the implications of moving, for example, on a downstage diagonal as opposed to a diagonal headed upstage, but these implications are not often clearly articulated in the way ballet is taught and are not necessarily understood explicitly by the audience. This reveals a more general trend in ballet over time: while the desired aesthetics of ballet have remained for the most part consistent, the meaning (in terms of both cultural and historical origins) have somewhat disappeared from understanding and from teaching. This paper therefore intends to bring back to the forefront the intentions behind the aesthetics of ballet so that a dance form that has become very academic and notoriously inexpressive can gain expressive quality through the reconnection to the original intentions of the art, and so that this return to expression can be translated most effectively to an audience.

The attention to mathematical perfection was not limited to floor patterns but instead extended to the human body itself. Pontus de Tyard described the mathematical logic of the body, with the observation that "the spread of the two arms and the extreme opening of the legs

correspond to the height of man: as does the length of the head multiplied eight or nine or ten times, according to different statues" (Homans 2008, 21), which justified the claims that disciplining the body to music and mathematics could "evoke celestial harmonies" (Homans 2008, 21).

While the form of ballet has changed dramatically from that of court dance in the sixteenth and seventeenth centuries, the concept of perfection through mathematics developed in that time period remains an integral part of ballet's aesthetic. While different choreographers over time have called for more naturalistic placement of bodies onstage, the image of symmetry still reigns supreme, as many ballets in the classical vein performed today continue to place the *corps de ballet* in symmetrical, or at least harmoniously asymmetrical formations, for example, those that are balanced spatially even if they are not exactly symmetrical. Even in times when expression and naturalness were favored over technique and visual perfection, the importance of symmetry and line was just as important a part of the ballet aesthetic as it was in earlier centuries. One example can be found during Fokine's time as choreographer for the Ballets Russes during the early decades of the 20th century. The *corps de ballet* in Fokine's *Les Sylphides* (1909) melts seamlessly from small circular groupings to several straight lines and back into a large circle. In ballets as diverse as *Swan Lake* (1877), *Le Spectre de la Rose* (1911), and *Scheherazade* (1910), solo dancers trace the same diagonal lines and arcs in space over the course of their respective variations.

The basic positions of ballet similarly reflect this concept of symmetry by balancing one body part with another: *tendu croisé devant* counterbalances the energy and line of the *tendu* leg with the *épaulement* of the upper body, while *arabesque* works to create the longest line possible, reaching from the tip of the finger to the ends of the toes. *Tendu à la seconde*

emphasizes the full width of the body in the horizontal plane, with fingertips and toes reaching to their fullest extension while the carriage of the arms suggests half of a circle. Even steps that are not necessarily seen as emphasizing position or shape involve a certain sort of geometry; a *pirouette* can be understood as simply the geometric form created in *passé* being revolved on a straight vertical line so it can be seen from all points of view.

Another product of the Enlightenment dance is its focus on control. Since one could improve oneself through learning, and dance afforded a means of attaining greater perfection, or a greater proximity to divine order, court dance came to emphasize precision of movement and nobility of comportment. In the court of Louis XIV, a courtier's ability to dance directly affected his social standing (Lee 2002). Movement had to be precise, with all unseemly elements eliminated. Control continues to be greatly emphasized in ballet technique, as the entire structure of classical variations demands an enormous amount of discipline, a skill developed through years and years of minute class-work. As will be described further in later sections, the invention of pointe shoes and pointework can also be seen as a logical endpoint of Empiricism, which, in making the world more intelligible, also "allowed men and women…to feel more at home in the world, and *more the masters of it*" (Chisick 2005, 14) [emphasis added]. Pointework emphasizes both the furthest extension of a possible line as well as the highest level of discipline and control of a dancer over her (natural) body.

The ideas of the Enlightenment created, and sustain, a concept of ballet as an art of truth. To many who study ballet, it seems that ballet has its particular aesthetic, form, and values not because it reflects the ideals of a particular cultural time and place but because it reflects *truth*, beauty through infallible logic. A young dancer accepts *croisé* as a position because she is told that is it correct; a more mature dancer may instead see *croisé* in terms of its symmetries and

shape and therefore determine that it is correct. Very few ballet dancers question the concept of symmetry and perfection as ultimate beauty, even though many other cultural dance forms do not value symmetry or define beauty in the same way. By seeing ballet not as a universal truth but as a cultural form, ballet dancers and choreographers can expand the perspective they take in approaching their art form, tying in conclusions and aesthetic choices not even accessible to them without this historical background. This allows a more critical approach to the dance form, and encourages dancers to understand more fully the aesthetic choices they make in each combination or variation rather than accepting them without question.

**The Romantic Era: Weightlessness, Ethereality, and Paradoxical Control over Nature**

Though strongly contrary to the empirical ideals of the Enlightenment as well as the monotheism of Christianity, a significant part of European cultural traditions included the belief in magic and supernatural creatures, and this tradition, suppressed during the Enlightenment, came back to center stage, if only in the context of metaphor, with the advent of Romanticism in the nineteenth century (Lee 2002). Romanticism was essentially a direct response to the empirical rationalism of the Enlightenment, emphasizing expression and the irrational over reason and the rational. In this discussion, irrational is used to mean that which cannot be explained through rational empiricism. However, Romanticism's "desire to transcend the human condition" (Lee 2002, 133) was still not very far removed from the Enlightenment's goal of achieving a more perfect self.

In addition to moving to preserve folk tales and traditions of the supernatural, Romanticism also reintroduced the ideal of courtly love and chivalry, opening the floor to the sentimentality markedly absent from Enlightenment era art. Ballet was a particularly compelling vehicle for this expressiveness: as Carol Lee explains, "because ballet production incorporated

transcendentalist literary ideas, reinforced by visual and aural forces, theatrical dance was rendered a powerful medium of expression. The combined elements of plot, décor, and music were made wonderfully vivid by choreography purposely devised to convey the dramatic content through the work of dancers" (2002, 138). Rather than reflecting the glory of a particular dancer or ideal, as court dance often did, the combination of the above elements was specifically intended to heighten the emotional and narrative power of a work. As well as setting the stage for the quintessential story ballet, this requirement of music, dance, and theme being harmonious in order to convey meaning would be echoed as a recurring theme in dance choreography, resurfacing, for example, during the era of the Ballets Russes.

The combination of these ideas of courtly love and the supernatural set the stage perfectly for the emergence of the sylph and the wili as the primary subjects of Romantic ballets. Dr. Paracelsus described sylphs as "extracts of previously living people. They were mortals, but without souls. Inhabiting the air, they were able to transmute back and forth between states of being and non-being" (Lee 2002, 136). Wilis were a more specific subset of sylphs, young women who had died on the eve of their wedding day. Thus the sylph/wili creature represented the pure, the supernatural, the ethereal, the irrational. The transformation from rational to irrational subject matter in dance was aided in part by Gothic melodrama, for "after forty years of this type of dramatic fare [Gothic melodramatic novels], theatergoers were conditioned to accept the irrational as normal. Therefore, when Romantic-style ballet began to take hold, with its love of all things mysterious, audiences were prepared to revel in its implausible conceptual and visual format" (Lee 2002, 140). While Lee and Dr. Paracelsus explain wilis and sylphs as soulless, they can also be understood, in the tradition of Cartesian dualism, as the soul detached from the physical body, which aligns well with the idea of purity that courtly love carried into

Romantic ballet. The history and aesthetic implications of courtly love will be discussed in more depth below.

While the time periods do not coincide exactly, literature and the study of the brain underwent parallel transformations over the course of the nineteenth century. Just as focus shifted from the purely logical to the emotional in the first half of the century, the perspective on the brain moved from the modular localization of Franz Joseph Gall's phrenology to a more diffusionist attitude and increased attention toward the unconscious and automatic, as explored by John Hughlings Jackson and William Carpenter in the late 1800's. Hughlings Jackson, concerned mostly with epilepsy, proposed a hierarchical organization of the brain, ranging from vital functions and reflexes to complex cognitive processes. However, rather than these systems being discrete and independent, each higher level depended upon and further specialized the function of the lower levels. The highest levels of function also had their sublevels, corresponding to different gradations and states of mind. Included in these gradations were unconscious and automatic processes. According to Hughlings Jackson, writing in the latter half of the nineteenth century, a disturbance to the system, for example, an epileptic fit, could knock out the highest level of functioning and reveal the unconscious, often automatic processes just below (Hughlings Jackson 1958, 123). William Carpenter goes one step further, describing unconscious processes not as a symptom of pathology but as a part of normal functioning, a phenomenon he terms "unconscious cerebration" (Carpenter 1881, 515) An example of this process is being unable to think of a particular name or word until one thinks about something else for a while, and then "it will often occur *spontaneously* a little while afterwards, suddenly flashing (as it were) into our consciousness" (Carpenter 1881, 519). This attention to automatic processes and the unconscious would set the stage for Freud's famous psychoanalytic theory, but

it is also important in allowing humans to be seen as other than entirely rational agents, reflecting trends of Romantic thought.

Since the main storyline of the Romantic ballets invariably included some sort of supernatural female creature, choreographers and dancers consciously worked toward creating the effect of weightlessness necessary to portray the ethereality of the sylph. The methods were diverse: focusing on increasing *ballon*, the quality of vertical lightness in a dancer's step; suspending dancers on wires for short amounts of time to create the illusion of them floating across the stage; the pas de deux necessitated by the instability of the ballerina *en pointe* but whose tenderness was consistent with themes of romantic love; and the development of female pointework.

While rising onto pointes was originally used by the male *danseur noble* as a preparation for jumps (Noll 1987), it was with the Romantic ballerina that pointework achieved the quality and importance that it has today. The first pointe shoes were essentially ballet slippers darned in the toes (Lee 2002, 141)—very different from today's sturdy, blocked shoes—which necessitated a floating, fleeting quality of movement rather than a strong, sustained balance. Because the image of defying gravity was so desirable, and the pointe shoe so effective in achieving this effect, it soon became *de rigueur* for Romantic ballerinas, and now is seen as an indispensible aspect of classical ballet.

Today, the ideas of weightlessness and ethereality can be seen as the defining characteristics and aesthetics of ballet, both on and off pointe. Modern dance revolutionary Martha Graham, among others, forcefully rejected the lightness of ballet dance and opted instead for a grounded, more weighted movement quality. While pointework has developed since the Romantic era to emphasize strength over lightness, thanks mostly to blocked shoes and the

choreographic innovation of Marius Petipa, the imagery of lightness, suspension, and ethereality still reigns supreme in ballet. Weightlessness and defiance of gravity can be seen in the suspension, *ballon*, and musicality of ballet. In *adagio* and *petit allegro* especially, but in many other places as well, the goal is to create the image of suspending a movement, holding it out until the last possible second so that it appears to never definitively reach its destination. This is evident in the musicality typical of ballet, in which the height of jumps and the ends of movements are emphasized musically more than transition steps. While appearing soft and immaterial, this effect ultimately requires a great deal of control, as dancers must employ the laws of physics to create the illusion of defying gravity. When listening to an audience watching a ballet, or a group of ballet students watching performances of their favorite ballerinas, the moments that elicit audible sighs of appreciation are those where the dancer sustains a movement just beyond what the music calls for, extends a leg for just a moment more, seems to stay in the air longer in a jump than gravity *should* allow. The most magical, irrational moments of ballet even today come from those moments where a dancer seems just beyond the laws of physics.

The goal of ethereality introduces a paradox of sorts in ballet: reliance on the laws of physics as a way to explain and understand the world contrasted with a defiance of the laws of physics to create the effect of weightlessness, an apparent clash between the Enlightenment ideas and Romantic ideals underlying ballet. However, the aesthetic results of these two aims are not in fact contradictory; instead they combine to create another defining characteristic of ballet: that of tension and yearning.

**The Ideologies Meet: Transcendence and Yearning**

Romantic ballet of the nineteenth century strove to display the irrational, emotional, and supernatural onstage, but required the rational, the control over nature resulting from the

Enlightenment, to attain this feat. While the effect seems paradoxical, in reality, the Enlightenment and the Romantic era have enough in common that they instead work together to create yet another particular aesthetic of ballet as it is understood today.

In the preface to Victor Hugo's *Cromwell* (1827), Hugo outlines a basic history of theatrical art, differentiating ancient and modern (Romantic) art through the absence or presence of the grotesque in art. In his argument, he claims that ancient art attempts to represent the world as perfect and whole while Romantic art identifies both the existence and the necessity of the grotesque in both art and life. He argues that neither the grotesque nor the sublime is sufficient on its own to represent reality, and describes "that contrast of every day, that struggle of every moment, between two opposing principles which are ever face to face in life, and which dispute possession of men from the cradle to the tomb" (Hugo 1909, paragraph 59). Sylphs and love stories did not alone characterize Romanticism; there was also a sense of conflict between the idea of perfection and its actual attainability. The Cartesian concept of mind-body dualism still held currency, and many Romantic authors, Hugo included, illustrated the desire to transcend, to move toward the ethereal soul and heaven, all the while being weighed down by the inescapable physical body.

In both the Enlightenment and Romanticism, there exists an idea of transcending the limits of man, either by moving up the ladder of universal order through self-improvement, as in humanism's view of ballet as an instrument of moral improvement, or through desiring to escape the bounds of the physical body. In identifying the discrepancy between perfection and the reality of man's position on the chain of being, this blend of ideas created a space for longing and yearning towards the perfection described by Enlightenment, which was argued unattainable by Romanticism.

Perhaps more important than the tension between the grotesque and the sublime during the Romantic Era was the concept of unattainable, courtly, or romantic love. For Gaston Paris, possibly the first to use the term "courtly love" (Wollock 2011, 31), the process of courtly love was more important than its consummation, as love itself was an "ennobling discipline" (Wollock 2011, 31). Often, courtly love was characterized by the unattainable nature of the object of affection, fitting with the focus on the struggling process of love rather than its achievement. This concept of unattainable love as desirable love was not limited to the time of the troubadours, but resurfaced with the advent of the Romantic Movement in art and literature. One Romantic author, Stendhal, "focus[ed] on courtship as the *highest* form of human happiness, on the educational value of love, and in particular of suffering on the part of the lover…all in line with the ideals of the troubadours" [emphasis added] (Wollock 2011, 234). In some ways, the suffering for the unachievable love was the most romantic part of courtly love. Besides Stendhal, other Romantic authors took up this theme of romantic love, most notably for the subject at hand, Theophile Gaultier, co-author of the libretto for the ballet *Giselle* (1841). Examining Gaultier's work shows how the idea of ideal love helped shape the literature of the time. Most of his stories tell the tale of a young man searching for some ideal but being hindered from achieving it by some aspect of reality, inevitably reaching some sort of tragic end, if only psychologically tragic. "Whatever happens, he experiences such intense regret that he can never henceforth be happy. Nor can he recapture his ideal if contact is once broken' (Smith 1969, 11). Albert B. Smith argues in his book *Ideal and Reality in the Fictional Narratives of Theophile Gautier* that Gaultier's concepts of the idealist, the ideal, and the reality that prevents the attainment or enjoyment of this ideal at a particular moment can be seen in the characters of the hero, heroine, and guide, respectively, in each of his stories (1969, 6-8). The inevitable disappointment that

results from searching for this ideal epitomizes the yearning that would come to be an integral part of the aesthetic of ballet.

This yearning is made manifest physically and visually in the steps and shapes of ballet. The line and symmetry resulting from Enlightenment concepts of mathematical perfection now carry added emotional content. Ballet history is characterized by a constant conflict between those who wish to emphasize technical virtuosity and those who prefer emotional expressivity in dance. Combining Romantic and Enlightenment ideals allows for a compromise, or perhaps a synthesis: the attempts at the highest beauty in form are now imbued with a tension and reaching quality indicative of the impossibility of achieving perfection and transcendence. Lines were no longer used simply to create pleasing symmetry, but also to convey this yearning through the fullest extension of the body in space, and also to add a degree of narrative tension. Even today, in ballets without thematic elements concerning unattainable desires, ballet's form itself reflects the conflict instilled by the varied historical ideologies of European culture. For example, William Forsythe's iconic *In the Middle, Somewhat Elevated* (1987) emphasizes shape and geometry through its references to Rudolph von Laban's nine-point cube that subdivides dance space to render it recordable. Despite this explicit attention to geometry, the partnering and even the solo work is imbued with a tension that exaggerates these shapes, stretching them past the traditional aesthetics of the dance form, manifested in jutting hips and off-balance extensions. In one captivating moment, a female dancer swings from a high fan kick into a deep, off-balance lunge, arms and back leg fully extended, maintaining equilibrium entirely due to her partner's counterbalanced weight. Often, these moments of extreme tension release into floating assisted jumps, or small, relaxed movements, like the isolated hip circles following the deep lunge. The stretching quality embodied by the dancers becomes even more apparent in these interspersed

moments of relaxed walking and swinging arms. Though the ballet has no narrative meaning, Forsythe's interest in breaking down and exploring the constituent parts of traditional ballet results in a work that reveals and emphasizes the aesthetic principles of ballet that are at times forgotten.

**Historical Conclusions: Understanding the Aesthetic**

Ballet as it is known today, though it is not often acknowledged as such, is a product of the cultural milieu in which it developed. Joann Kealiinohomoku, in her landmark assertion of ballet as an ethnic dance first published in 1970, defines an ethnic group in anthropological terms as "a group which holds in common genetic, linguistic, and cultural ties" (2001, 39), concluding that "by definition, therefore, every dance form must be an ethnic form" (2001, 39). She goes on to point out several of the influences of European ethnicity on ballet, including the occupations, flora, fauna, and storylines highlighted in traditional ballet. She too discusses the aesthetic consequences of the cultural context of ballet's development.

As has been discussed in depth above, two movements that dramatically influenced the art form were the Enlightenment and the Romantic Era. The former introduced the idea of perfectibility of man and the divinity of number and order while the latter brought themes of courtly love and supernatural as well as established pointework as the realm of the ethereal ballerina. The consequences of both these movements are still evident in ballet today, with dancers creating shape and geometric form with their bodies, suspending the ends of steps to create a floating, supernatural aura, and striving for perfection in line. Through examining the historical contexts in which ballet was developed, the reasons behind the aesthetics of movement that exist today are more apparent. Dancers and teachers alike, by understanding these ideas, can both question and expand them in their dancing, teaching, and choreography.

While postmodern dance often claims to be opposed to ballet in ideals and form, it instead emerges from the same cultural context and shares many foci, although it may reject some ideas that ballet reveres. The deconstructive aspect of postmodern dance, the tendency to break dance into constituent parts and explore each part separately and exhaustively (for example, repetition and artifice in Pina Bausch's work, or accent of movement (or lack thereof) for Yvonne Rainer), is itself a product of the Enlightenment and the reductionist tendency of rationalism and empiricism to explain the world by breaking it down (Toulmin 1992). The aesthetic of some forms of postmodern dance, as well as the field of contemporary ballet, tends to have some basis in shape, form, and line, either rejecting it overtly or allowing it to shape the movement. Ballet and postmodern dance are descendants of the same cultural lineage, and postmodern dance can be seen as an explicit identification and exploration of the concepts underlying classical ballet. Postmodern choreographers either embrace these ideas and aesthetics and deepen them in some way, or reject them outright; ignorance of these ideals in creating postmodern work is nearly impossible. For example, as mentioned above, Forsythe heavily emphasizes the geometric basis of the balletic form through his use of the Laban cube as an improvisational and compositional tool. Conversely, Alonzo King enters in conversation with the concept of weightlessness in ballet by emphasizing the transitions between movements rather than the peaks of movement (positions) in his pointe-based choreography, by extension showing effort rather than traditional ease (Nunes Jensen 2005, 40). In his ballet *Dust and Light* (2009), a soloist swipes across the space with arms crossed in a modified, extended prayer position, feet in a wide parallel second. Then her hip turns her foot in, starting a progression of other movements that seem to unfold seamlessly from the dancer's body: hip, elbow, shoulders, back rotate and undulate to follow the foot's impetus. More important than the shape of each slightly distorted

position is the way these positions melt into and are created by each other, a contrast from the imagery of ballet. By better comprehending the cultural nature of ballet and, more broadly, aesthetics employed in Western dance, choreographers and dancers allow themselves the opportunity for choice and deeper understanding that they would not enjoy without this historical viewpoint.

**Applying the Aesthetic**

Knowing this historical and aesthetic background is all very nice, but how can it help a performing artist? Many dancers take an "unthinking" approach to their art form (Laws 2002, 4), differentiating (in line with Cartesian dualism) between their bodies, which they deem crucial to their profession, and their minds, which are seen as useless or even as detractors from a dancer's expressive ability. However, understanding the history, aesthetics, and mechanics of ballet can help a dancer immensely, with regards both to their technique and their artistry. Kenneth Laws has written a highly informative book entitled *Physics and the Art of Dance: Understanding Movement* (2002) in which he explains the basics of ballet through conceptual physics: balance, motions without turns, pirouettes, turns in the air, and the pas de deux are each dedicated their own chapter. While his work provides many insights into how to most effectively execute the technical demands of ballet, he does very little to explain how a dancer can use physics to expand their artistic range. As outlined above, the historical and cultural milieu in which ballet developed creates a paradox of using physics to appear to defy physics. In this section, I will expand the work of Laws to explain how a dancer can use an understanding of the laws of physics to create the illusion that she is not bound by these laws, though of course the only way she can create this illusion is by applying these very physical laws.

While science is often seen as being separate from and unaffected by culture, certain cultural traditions that helped shape ballet are also present in scientific inquiry, namely, that of seeking to attain the unattainable. Physics and other sciences break things down into smaller and smaller pieces with the goal of understanding some essential truth about them, but the same disconnect exists between ideal and reality in this field as that which defined the Enlightenment's quest for perfection and the Romantic era's desire to transcend the physical. Though a perfect, entirely accurate truth about the physical world is unlikely to be found, the ideal still motivates work in physics and other sciences, showing that even the scientific method is steeped in cultural and historical influences. Even though this complete and accurate modeling of the world cannot be achieved, the steps taken toward the ideal truth do serve to deepen our comprehension of the world around us. Concerning the topic at hand, an exploration of physics, though it cannot describe the entirety of what goes into creating certain illusions, helps to hone in on one aspect of how the necessary illusions are created and allows for increased understanding of the form overall.

**Vertical Jumps: Increasing *Ballon***

A relatively simple way to appear to escape the clutches of gravity is by increasing airtime in jumps in petit allegro. A very common problem for dancers is improper coordination of the arms and legs in jumps. Often it can seem to the dancer as though this correction is arbitrary, but in fact, if the arms are used correctly, a dancer can achieve an increase of an average of 25% in height in his or her jump (Laws 2002, 45). Since increasing *ballon*, or time spent in the air, is an important way to create the appearance of weightlessness, understanding the most effective use of the arms in achieving height (and accompanying increase in air time) is very helpful for a dancer working to create the visual illusions of ballet. Very fundamentally, the

number of forces that can act on the dancer is very limited: the downward force of gravity and the upward force from the floor. In order to create any acceleration or movement, the dancer must exert a force on the floor in a particular direction. If the dancer leaves the floor at any time, as during a jump, gravity is the only force acting on her. The height of a vertical jump is determined by the vertical distance through which force is exerted (roughly translated to the depth of the plié) and the ratio of the downward force to the dancers weight (Laws 2002, 44). Furthermore, if a dancer's arms move relative to the rest of her body during the jump, they can store more vertical momentum than if there was no relative motion. This momentum can then be transferred to the rest of the body when the arms stop moving relative to the body. In this way, the momentum of the torso is increased, and the upward velocity of the dancer decreases less quickly due to gravity, increasing the time spent in the air. Many dancers start jumps with their arms extended to the side, and then bring them down through the center and back up to reach the peak of the jump. Rather than being a stylistic add-on, this way of moving the arms is actually effective in creating one of the important illusions of ballet. For a more specific example: there are different schools of thought on the way a dancer should move her arms in a *jeté*. Some schools advocate for closing the arm from second position to first during the jump while others instead bring the arm from second through fifth en bas before bringing them to first position. Since the first practice introduces relative horizontal rather than vertical momentum, it does very little to increase the height of the dancer's jump, while, as explained above, the second method does significantly increase the jump's height. By recognizing different physical consequences of various technical choices, a dancer can determine which choices are simply stylistic and which are integral to developing the illusions of ballet.

But what does one do with all this extra time and height? And how does one stay with the music? By speeding up the preparation for a jump (without reducing the force into the floor, of course), a dancer can create more time in the music for a higher jump. One application is in the simple petit allegro combination *glissade assemblé.* Instead of using a full count to glissade and another to jump into the air, assemble the legs, and land, the dancer can instead use only the "and" count for the glissade. The assembled position can now be reached by count "one" and the dancer has a comparably huge amount of time to remain airborne, creating the appearance that he is weightless or unbound by the laws of physics. This also has the added benefit of highlighting the movement itself, since the altered musicality highlights what is important to the dancer and subsequently what the audience notices most: in this case, the peak of the jump. Thus, by coordinating her arms with the jump and altering her musicality, a dancer can find the most effective way of appearing to float just a moment longer than strictly natural in small vertical jumps.

**The Floating Grand Jeté**

One of the most visually stunning effects of ethereality comes in the illusion of a floating *grand jeté*. One leap in particular is especially famous: that of Vaslav Nijinsky, who contemporaries claimed would remain in the air for several seconds during his leaps. Clearly, this feat of defying gravity falls nicely into both the ideals of the Romantic era and those of the Enlightenment: it shows both a level of control over the laws of physics while also creating a supernatural and ethereal quality. But how does a dancer achieve this illusion? Luckily enough, the effect is built right into the mechanics of the jump, as Kenneth Laws elucidates in his book *Physics and the Art of Dance* (2002). A *grand jeté* usually follows a movement traveling horizontally, so when the dancer leaves the floor, her horizontal speed remains constant while

her vertical speed decreases until it reaches zero at the peak of her jump, then increases in the downward direction until she lands again. Combined, these create a parabolic trajectory for the center of gravity to follow. If the body is subject to the laws of physics, how is it possible that a ballerina can appear to hover for a few moments at the peak of her jump before descending? As Laws points out, "unlike a simple object such as a ball, the human body can change its configuration during the time in the air, giving rise to some interesting phenomena" (Laws 2002, 43). Specifically, a dancer can alter her center of gravity through altering the position of her arms and legs. As the dancer's arms and legs move into the desired split position, her center of gravity also moves higher relative to the rest of the body, from perhaps the belly button to the center of the chest. As the center of gravity reaches its peak, its moment of zero vertical velocity, the dancer's head is actually lower than if she could not change her form, as the distance between the center of gravity and the head is smallest when the center of gravity is higher within the body. On the descent from the jump, however, as the arms and legs move toward the floor again, the center of gravity lowers relative to the body, allowing the head to descend more slowly and creating the illusion of suspension. The center of gravity of the dancer follows the trajectory dictated by the laws of physics while the dancer's head follows a slightly flatter arc, giving the illusion of hovering for a moment in midair, traveling horizontally. However, timing is important: "the split must be timed to coincide with the peak of the curved path of the body's center of gravity in order to produce the smoothest appearance of horizontal motion" (Laws 2002, 49). A dancer, by experimenting with the timing of her split in the jump, can find the most effective means of creating this particular aesthetic floating. The landing of the jump too is important, in several different ways. First, as explained above, the lowering of the arms and legs after the peak of the jump in turn lowers the center of gravity. Since the center of gravity (rather

than the center of the body) follows the parabolic trajectory, the torso remains higher in the air longer, creating the illusion of a longer-lasting jump. In terms of the actual impact onto the floor, the dancer should, according to the aesthetic goals outlined above, try to create a soft, silent landing to show weightlessness. This can be achieved by rolling through the foot and increasing the depth of the plié. By increasing the plié's depth, the time and distance over which the body must slow from free-fall velocity to zero velocity is increased, meaning that the average force on the floor can decrease, as the impulse, or total change in momentum, is the same regardless of time (Laws 2002). Both the slower descent and the delayed landing help create the illusion of floating weightlessness. It is up to the dancer, then, to find the best combination between these two to achieve the aesthetic goals of ballet. For example, bringing both the arms and legs down may keep the torso in the air longer, but a ballerina may decide to leave her arms in the air throughout the landing of the jump in order to avoid appearing as if she fell out of a tree. Instead, while leaving her arms up and soft, she can lower her legs more quickly but lengthen the time of her plié through resistance to create a softer landing and the illusion of being weightless.

**A *Meta*physical Approach: Visualizing Pendulums**

An understanding of physics does more than simply make it easier for the dancer to achieve certain feats and illusions; it also allows the dancer to apply concepts of physics to movements and steps that are less obviously dictated by physics, and through this application, to appear to transcend these laws of physics as well. For example, comprehending the physics of a pendulum can help a dancer find steps that include and mimic this pendulum movement and then manipulate them in a way that defies physical expectation. Just one of the many steps that include pendulum-like dynamics is the *temps lié* forward and back.

The movement of a pendulum can be explained by the translation of energy from potential to kinetic and back again as the pendulum swings through its arc. To begin, we need to understand the concepts of potential and kinetic energy. Potential energy is the energy an object has by virtue of its position in space. In the case of a pendulum, the potential energy (PE) is the mass of the pendulum (m) times the acceleration due to gravity (g) times the height of the pendulum (h) above whatever height has been determined to be zero, or PE=mgh. Kinetic energy (KE) is the energy an object has due to its motion. This quantity is dependent on both the mass of the object (m) and the speed of the object (v) and can be described by equation $KE=1/2mv^2$. According to the Law of Conservation of Energy, energy can be neither created nor destroyed, only translated from one form to another. In relation to a pendulum, the initial potential energy is determined by the initial height to which it is raised, and this potential energy is the total energy of the system when the pendulum is released and begins to swing, since at the start point it has no velocity and therefore no kinetic energy. Since energy cannot be created or destroyed, as the pendulum swings lower and its potential energy decreases, the velocity of the pendulum must increase so that the sum of kinetic and potential energies remains constant. When the height of the pendulum is lowest, its velocity is greatest, and vice versa. At either peak of the pendulum's swing, the velocity drops for a moment to zero as the pendulum changes its direction. As we saw with the floating *grand jeté* example, the moment of zero velocity is important in creating the illusion of being outside the control of gravity. If a dancer can in any way prolong that single moment, she is able to use her grasp of physics to create the illusion of ethereality. Conversely, the dancer can manipulate the downswing of this pendulum like movement, increasing or decreasing the speed of descent to alter the image created.

But where does pendulum-like movement appear in ballet? The idea of a pendulum is related to the idea of undercurve, the upside-down parabola shape metaphysically created by certain steps or movements. In emphasizing suggested arcs in space, the undercurve follows Enlightenment traditions of geometry, but it allows the possibilities of weightlessness and tension as well. Undercurve is crucial to the *temps lié*, a step in which the dancer shifts her weight from entirely on her back foot to entirely on her front foot while travelling forward in space. If the *temps lié* can be described like a pendulum, then the extension at the ends of the movement should be moments of zero velocity while the *plié* linking the two final positions should be the moment of greatest velocity. If a dancer takes advantage of this moment of zero velocity at the peak of a pendulum swing, she can translate it to her *temps lié* by sustaining that single moment of peak, of zero velocity, just beyond the time gravity would allow before the pendulum begins its swing back to the equilibrium position.

Like the *grand jeté* example, this "manipulation" of physics creates both a sense of the dancer's control over nature and her being supernatural, unaffected by natural forces like gravity. However, the *temps lié* example offers something the *grand jeté* example lacks: a sense of tension. A *grand jeté* and the projectile motion that describes it move forward constantly in the horizontal direction while a *temps lié*, or rather, a series of *temps liés*, involves a change in direction horizontally. For a pendulum, the tension in the string or rod that is supporting the weight of the pendulum provides a force that changes direction over time throughout the pendulum's swing. Acceleration (a), which is a vector quantity (includes a directional component), depends on the mass of an object and the net force (F) acting on that object (F=ma). Throughout the pendulum's swing, the direction of the net force changes as the direction of the force due to tension in the pendulum's support changes direction relative to the constant

downward force of gravity. As the pendulum swings from equilibrium (lowest position) to its peak, the acceleration of the pendulum is roughly opposite to the direction of its velocity, eventually slowing the pendulum weight down to zero velocity, a point of interest for the dancer. While lingering for a moment in the peak of the movement to create the ethereal aesthetic, the dancer can also explore the tension of the body that derives from changing directions. By keeping the arm reaching to arabesque even as she begins her return to "equilibrium," a dancer can magnify the tension of the direction change, the conflict between velocity and acceleration. This look of tension, of striving in one direction while being pulled in another, fits perfectly with the Romantic era sentiments of the impossibility of achieving the perfection advocated for by the Enlightenment. This tension is also a quality that tends to remain in the Euro-American dance traditions even when the ideas of lightness and ethereality or form are rejected outright. Only by understanding both the physics of ballet and the history of its values and aesthetic goals can a dancer begin to combine the two to create visually compelling and physically effective representations of the artistic and cultural goals of the art form of ballet.

**Ballet Aesthetics and Audience Perception**

The previous section discusses the means by which a dancer can produce the illusions characteristic of ballet, but this tells only half the story. Equally important as creating the necessary images is the understanding of those images, the audience's perception and recognition of the intended messages. This third and final section will attempt to answer the question: How effective are the aforementioned illusions in conveying, to various audiences, the values of the culture in which ballet developed?

There are many possible approaches to answering this question, from philosophy to phenomenology to interviews with those who frequent dance performances, but the approach I have opted for is a neuroscientific one. While many see the presumed invasion of neuroscience into the realm of the arts as unnecessary and even harmful to the arts and humanities, William B. Seeley, in his treatise on the neuroscience of dance, points out the similarities between artwork, essentially communicative devices, and cognitive neuroscience, which concerns itself with investigating how people "acquire, represent, manipulate, and use information" (Seeley 2013, 52). Neuroscience is not necessarily the be-all-and end-all explanation of dance, but it can serve as another way of understanding the process of translation between choreographer or dancer and audience member. In addition, neuroscience can be seen as the contemporary continuation of the ideas promoted by the Enlightenment: those of order, of logical explanations of observable phenomena, and interest in the brain as the seat of reason. As with the study of physics, another important similarity with both the Enlightenment and the Romantic era is neuroscience's attempt to understand entirely the phenomena of the brain, a feat that will likely never be achieved. Neuroscience's deconstructive approach towards studying the working of the abstract mind creates an interesting conversation and tension, as it argues that the best way to understand the subjective is to make it as objective as possible, moving from abstract to concrete. Breaking down the different parts of brain and behavior allows researchers to move closer to some essentially true understanding of the brain, even if this understanding is fundamentally unattainable.

The study of dance neuroscience presents a whole host of difficulties that have constrained the nascent field. For one, research in humans has to be limited to noninvasive neuro-imaging techniques, as in any neuroscience study, but the study of dance using

neuroscience presents several unique challenges. Functional magnetic resonance imaging (fMRI) scanning requires complete stillness from the participant, so this technique cannot be used on a dancer to determine exactly how, for example, the process of embodying disembodiment, creating the image of immateriality through the use of a physical body, occurs neurologically. Dance audience members can be studied in fMRI, as their tasks would not require movement, but watching videos rather than live performances of ballet and other dance forms could lead to slightly different results. In terms of practicality, studying dance using neuro-imaging techniques is frankly economically unfeasible, as its real (non-dance) world applications are limited and unlikely to find funding easily. Fortunately, however, other neuroscience studies in areas such as music, physics, and motion can serve as models from which to speculate on the possible involvement of the brain in observing dance. Still, difficulties exist in this translation as well, as many studies of music and motion, and even the few existing studies of dance, focus on how emotions are experienced from the formal elements of composition, whereas ballet is more often concerned with conveying a formal message, or a message about the values of a culture, than with projecting certain emotions in the way that modern dance does.

With these limitations and difficulties in mind, we return to the question posed above: How effective are the aforementioned illusions in conveying, to various audiences, the values of the culture in which ballet developed? One part of this question we must define is the idea of "various audiences." The first section of this paper shows how inherently tied to European culture ballet is, so in order to determine its efficacy in displaying the values of this culture, we must ask to what extent the comprehension of its illusions are dependent on cultural knowledge. Is the show of weightlessness in a *grand jeté* effective for only ballet dancers in the audience? For Western audiences in general? For all audiences, regardless of culture? Neuroscientific

studies of music may help in this regard, as ballet and European music share many of the same features, including the idea of tension and resolution. It seems likely that some aspects of comprehending the aesthetics of ballet will be culturally specific, like the appreciation of symmetry and geometric form more generally, while others are more likely to be universal, especially the aspect of defying the laws of physics. In our exploration of the neuroscience literature than pertains to dance, we will keep this question of cultural vs. universal in the back of our minds.

An ongoing debate in the nature of dance experience that will affect which neuroscientific studies are relevant for answering the above question is whether an audience's experience of dance is primarily visual or primarily kinesthetic. In other words, do audiences experience dance through the shapes they see or through some sort of mirrored motor response? For the purposes of this paper, we will use Noel Carroll and William P Seeley's concept of an "integrated, crossmodal, *projective kinesthetic perceptual capacity* that engages embodied motoric, skeletomuscular, somatosensory, visual, and auditory processes" (Carroll and Seeley 2013) and examine studies in both kinesthetic and visual fields.

The question of symmetry in dance is perhaps the most easily translated to other forms of art, and so a general discussion of the growing field of neuroaesthetics may give insight into how the idea of symmetry, order, and reason can be conveyed to the audience through the positioning of a dancer's body. Anjan Chatterjee, in his discussion of neuroaesthetics, discusses how the way the brain processes visual stimuli may give insight into how artworks are understood (Chatterjee 2011, 301). He explains that visual processing occurs in several different steps, with the brain first extracting simple visual elements such as "color, luminance, shape, motion, and location" (Chatterjee 2011, 301). The next step involves a structuring and organization of this rather

chaotic influx of information, grouping some elements together while separating others, possibly involving the extra-striate cortex (Chatterjee 2011, 302). The last step involves object recognition and association, in which meaning is attached. There is significant interaction between these levels, and factors such as the amount of time an image is displayed can influence which level most affects meaning. “Intriguingly, preference for form predominates when images are shown for short durations, while preference for detail predominates when images are shown for slightly longer times” (Chatterjee 2011, 302). As ballet involves sometimes rapid shifts between geometric shapes, both in space and in the body, this model may explain how the importance of form is conveyed to the audience. Chatterjee also discusses how the early levels of visual processing affect the frontal and parietal circuits that mediate attention, an example of Seeley’s argument that “artworks can be conceptualized as attentional engines, or stimuli intentionally designed to direct attention to their artistically salient diagnostic features” (Seeley 2013, 53). The artistically salient diagnostic features in ballet include its emphasis of symmetry and order, and the presentation of symmetrical form followed by symmetrical form can help prime the visual system to more easily recognize and attach meaning to the ordered shapes created. In William Forsythe’s *The Second Detail* (1991), the presentation of croisé positions followed by developpés à la seconde introduces the visual concept of symmetry and geometry, as each shape is presented for only a brief moment. This can then prime the visual system to pay attention to these geometric qualities for the rest of the piece, which additionally serve as the theme of the piece, in a formalist way.

Concerning symmetry in particular, Jacobsen et al (2006) conducted a study using fMRI to examine the brain correlates of aesthetic judgment. They found that, though different neural networks were active during judgment of geometric objects (similar in form to paper snowflakes)

as beautiful or symmetrical, one region, the left intraparietal sulcus, was activated both when objects were judged symmetrical and when they were judged to be beautiful (Jacobsen et al 2006, 282). In addition, twelve of the fifteen participants used symmetry as a deciding factor in judging the beauty of a geometric object, with one participant using it as his only judgment criterion for beauty. The behavioral and neural overlap suggests a place for symmetry in determining what is or is not beautiful, which is very relevant to the use of symmetry in ballet, which functions as a way of glorifying order. Unfortunately, the researchers make no mention of the cultural backgrounds of their participants. But as the study was conducted in Leipzig, Germany, it is very likely that the participants had similar cultural preferences as those who formed ballet. However, the question of cultural/universal remains and can be resolved only with further study, namely by presenting a paradigm similar to the above to various cultural groups and comparing results across groups.

How does the illusion of weightlessness work on the receiving end? One particularly compelling study builds on a previous study that shows that excitability of a certain area of the brain, the primary motor cortex (M1), represents the force necessary to lift a particular object (Alaerts et al 2010a). The study investigates which visual source conveys weight information best: the kinematics, the contraction state of the hand, or intrinsic properties of the object, like size or fullness. The researchers found, using transcranial magnetic stimulation (TMS) and measurement of motor evoked potentials (MEPs) in the hand, that activity induced by observation in M1 reflected the observed level of force necessary when information about kinematics or hand contraction state was available, with intrinsic object properties being less important (Alaerts et al 2010b, 2082). While the encoding of muscular force necessary to lift a glass of water may seem irrelevant to a discussion of audience perception of ballet's illusions, in

fact, this study suggests one way the illusion of weightlessness may "work." As explained above, the physics of a *grand jeté* involve an alteration of expected kinematics, as the dancer, unlike a uniform ball, can change her center of gravity by moving her limbs, allowing her head to follow a slightly flatter trajectory and appearing to delay her descent. If the conclusions of the Alaerts et al study can be extended to this balletic phenomenon, the altered kinematics of the dancer actually change the viewer's perception of her weight, so that they may in fact see her as actually weightless. While the researchers do not discuss the cultural backgrounds of the study participants, it seems likely that this process is universal rather than culturally limited, suggesting that the appearance of weightlessness at the height of a *grand jeté* could be understood by an audience member of any background. This idea of changed kinematics altering perceived weight can apply to any of the jumps discussed above, as each involves a deviation from the expected trajectory taken by the dancer in the air, both in the time spent near the peak of the jump as well as the increased landing time, intended to hide the effect of gravity on the body.

The question of tension, through the emotional quality embedded in it, can begin to be answered in several different ways. Western music and Western dance share many of the same qualities, with a key similarity being the interest in tension and release. David Huron and Elizabeth Hellmuth Margulis underline the importance of time and musical expectancy in eliciting both emotion and appreciation in music, invoking the involvement of the dopamine reward system with the experience of seeking or expectation, roughly translatable to the experience of tension (Huron and Margulis 1993). In a positron emission tomography (PET) study using [$^{11}$C]raclopride binding and measures of autonomic nervous system arousal, Salimpoor et al (2011) examine dopamine release in response to peak emotion in music. They show that different anatomical areas are activated (in an fMRI scan following the PET

procedure) in response to the anticipation (right caudate nucleus) and experience (right nucleus accumbens) of peak emotion, areas which show increased dopamine binding (Salimpoor et al 2011). Combined with Huron and Hellmuth Margulis's discussion of time, this musical study can be extended to dance to show that heightening anticipation can induce or enhance an emotional response in the audience. In relation to the above discussion of pendulums and *temps lié*, if a dancer manipulates the timing of the metaphysical pendulum swing to increase the tension temporally before its inevitable release in any step using an undercurve, she can elicit an emotional response from the audience. The emotional response may very well be expectation in and of itself. For example, a common step in class combinations and variations alike is a release from *chaîné* turns into a *tombé pas de bourrée*, often a pirouette preparation. If the dancer can extend temporally the moment just before the *tombé*, she creates anticipation in the viewer, excitement about what her next movement will be. Further research elucidating the role of anticipation and the dopamine reward system in viewing dance specifically could provide further support to this hypothesis.

Music is not the only way to understand how tension is translated to an audience, and it suffers a lack of kinesthetic involvement, integral to experiencing dance. Seeley argues that "the central claim of the neuroscience of dance is that our understanding of the expressive qualities of choreographed movements emerges from the role motor simulation, motor mimicry, and affective mimicry play in ordinary perceptual contexts" (Seeley 2013, 56). Edwin Denby, a poet and dance critic, describes an example of kinesthetic perception helping to clarify the meaning of a danced work, Vaslav Nijinsky's controversial *Prélude à l'apres-midi d'un faune* (1912):

> The fact is that when the body imitates these poses, the kind of tension resulting expresses exactly the emotion Nijinsky wants to express…both their actual tension and their apparent remoteness, both their plastic clarity and their emphasis by negation on the center of the body (it is always strained between the feet in profile and the shoulders en

> face)—all these qualities lead up to the complete realization of the faun's last gesture (Denby in Montero 2013).

As Barbara Gail Moreno explains, "through motor perception, Denby feels the tension of the dancer's bodily torque" (Moreno 2013). How exactly can this kinesthetic information be transferred from the dancer's body to the audience member's brain? Seeley argues that the premotor and limbic systems are involved in our ability to process dance, with premotor regions helping to mirror the movement presented (to a variable degree based on motor expertise of the viewer), and the limbic system involved in processing the emotions suggested through the bodily movements. He further argues that these regions feed back to the visual system to enhance attention to relevant stimuli, allowing the content of a work to influence low levels of sensory processing through corticothalamic and corticolimbic circuitry (Seeley 2013, 63). In this way, the reaching of an arabesque can be understood conceptually through the observed tension of the muscles, which reminds the viewer of the way that muscular tension feels, which can lead to an emotional response of yearning and reaching. Once this attention to yearning is established, the brain works to recognize other examples of this tension more easily, allowing a greater understanding of the danced character's emotional state. In Antony Tudor's *Jardin aux Lilas* (1936), Caroline's first restrained reach across the stage toward her lover, which involves tension in the torso contrasted with the reaching arm, sets up the audience to recognize the restraint and reaching in the rest of her variation, conveying her resignation to her arranged marriage combined with her desire to be with the man she truly loves.

The understanding of a ballet by an audience relies on many different neurological processes, ranging from the strictly visual to the primarily kinesthetic. These processes can help explain why exactly it is exciting to a see a dancer suspend herself in midair during a *grand jeté*, or what it is about a certain movement that makes it seem melancholic or exuberant, even in the

very formal and emotionally restrained form of ballet. Neuroscience is by no means the only way to understand the effectiveness of the art form in conveying its intended meanings and illusions, but it does present a replicable means of deconstructing ballet into its constituent parts to help understand the function of the whole, which is especially attractive in light of ballet's Enlightenment origins. In addition to a shared historical basis, neuroscience, and the approach of science more generally, shares a similar dynamic to ballet: the attempt to reach something ideal but fundamentally unattainable. For the Enlightenment era, this ideal was perfection, for the Romantic ballet, ethereality, and for science, the end goal, never reachable, is the discovery of complete truth. Each investigation attempts to understand one tiny fragment of the whole with the hopes that eventually, the entire truth will be constructed out of these fragments. Physics attempts to model each dimension of movement, but acknowledges the fact that objects in reality will move slightly differently than the model predicts. Though neuroscience may never have the tools to understand every aspect of human brain and behavior, research is motivated by the possibility of creating better and better models and understandings. This paper has followed this same line of thought, breaking down the historical, physical, and neuroscientific aspects of ballet in an attempt to understand the art form more completely, from the point of view of both a performer and a scientist.

Bibliography

Alaerts et al. *Force requirements of observed object lifting are encoded by the observer's motor system: A TMS-study.* European Journal of Neuroscience, 31, pp. 1144-1153, 2010.

Alaerts et al. *Observing how others lift light or heavy objects: Which visual cues mediate the encoding of muscular force in the primary motor cortex?* Neuropsychologia, 48, pp 2082-2090, 2010.

Carpenter, William. *Principles of Mental Physiology*. London: C. Kegan Paul & Co, 1881.

Carroll, Noël and William P. Seeley. "Kinesthetic Understanding and Appreciation in Dance." *The Journal of Aesthetics and Art Criticism* 71, no. 2 (2013): 177-186.

Chatterjee, Anjan. "Neuroaesthetics: Growing Pains of a New Discipline." In *Aesthetic Science: Connecting Minds, Brains, and Experience*, edited by Arthur P. Shimamura and Stephen E. Palmer. Oxford: Oxford University Press, 2011.

Chisick, Harvey. *Historical Dictionary of the Enlightenment*. Lanham, MD: Scarecrow Press, 2005.

Dear, Peter. "A Mechanical Microcosm: Bodily Passions, Good Manners, and Cartesian Mechanism." In *Science Incarnate: Historical Embodiments of Natural Knowledge*, edited by Christopher Lawrence and Steven Shapin. Chicago: University of Chicago Press, 1998.

Homans, Jennifer. *Apollo's Angels: A History of Ballet*. New York: Random House, 2010.

Homans, Jennifer. "Becoming Ballet: A History of Classical Ballet in France from its Origins through the Romantic Era." Ph.D. Dissertation, New York University, 2008.

Hughlings Jackson, John. "On Epilepsy and Epileptiform Convulsions." In *Selected Writings of John Hughlings Jackson*, edited by James Taylor. New York: Basic Books, Inc, 1958.

Hugo, Victor. "Preface to Cromwell." In *Prefaces and Prologues: To Famous Books,* edited by Charles W. Eliot. New York: P. F. Collier and Son, 1909.

Humphrey, Doris. *The Art of Making Dances*. New York: Rinehart, 1959

Huron, David and Hellmuth Margulis, Elizabeth. "Musical Expectancy and Thrills." In *Handbook of Music and Emotion: Theory, Research, Applications* edited by Patrik N. Juslin. Oxford: Oxford Scholarship Online, 1993.

Jacobsen et al. “Brain correlates of aesthetic judgment of beauty.” *NeuroImage* 29 (2006): 276-285.

Kealiinohomoku, Joann. "An Anthropologist Looks at Ballet as a Form of Ethnic Dance." In *Moving History/Dancing Cultures: A Dance History Reader*, edited by Ann Dils and Ann Cooper Albright, 33-43. Middletown, CT: Wesleyan, 2001.

Laws, Kenneth. *Physics and the Art of Dance: Understanding Movement*. Oxford: Oxford University Press, 2002.

Lee, Carol. *Ballet in Western Culture: A History of Its Origins and Evolution*. New York: Routledge, 2002.

Montero, Barbara Gail. “The Artist as Critic: Dance Training, Neuroscience, and Aesthetic Evaluation.” *The Journal of Aesthetics and Art Criticism* 71, no. 2 (2013). 169-175.

Noll Hammond, Sandra. “Searching for the Sylph: Documentation of Early Developments in Pointe Technique.” *Dance Research Journal* 19, no. 2 (1987): 27-31.

Nunes Jensen, Jill. “Re-Forming the Lines: A Critical Analysis of Alonzo King’s LINES Ballet.” Ph. D. Dissertation, University of California, Riverside, 2005.

Robinson, Daniel N. “Pythagoras and the Divinity of Number.” *Great Ideas of Philosophy, 2nd Edition*. Chantilly, Virginia: The Teaching Company, 2004.

Salimpoor et al. “Anatomically distinct dopamine release during anticipation and experience of peak emotion to music.” *Nature Neuroscience* 14 (2011): 257-262.

Seeley, William P. “Movement, Gesture, and Meaning: A Sensorimotor Model for Audience Engagement with Dance.” In *Moving Imagination: Explorations of Gesture and Inner Movement*, edited by Helena de Preester, 51-68. Philadelphia: John Benjamins Publishing Company, 2013.

Smith, Albert B. *Ideal and Reality in the Fictional Narratives of Theophile Gaultier*. Gainesville: University of Florida Press, 1969.

Toulmin, Stephen. *Cosmopolis: The Hidden Agenda of Modernity*. Chicago: University of Chicago Press, 1992.

Wollock, Jennifer G. *Rethinking Chivalry and Courtly Love*. Santa Barbara, California: Praeger, 2011.

Acknowledgments

I would like to thank my advisor, Professor Tyler Walters; my committee, Professor Julie Janus Walters and Dr. Purnima Shah; Professor Barbara Dickinson; and my family for their help throughout the entire process of writing this paper.